AN ABSTRACT OF SOME OF THE RESULTS OF MEASUREMENTS AND EXAMINATIONS OF THE PHOTOGRAPHS OF THE TOTAL SOLAR ECLIPSE OF AUGUST 7, 1869.

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I have the honor to lay before the American Philosophical Society a few results of my measurements and examinations of the Photographs of the Total Solar Eclipse of Aug. 7, 1869, taken at Burlington, Iowa.

The Photographic expedition, of which these photographs are part of its results, was organized by Prof. Henry Morton of Philadelphia, under the authority of Prof. J. H. C. Coffin, U. S. N., Superintendent of the American Nautical Almanac.

The expedition occupied three stations in Iowa; viz. Burlington, Mt. Pleasant and Ottumwa, respectively under the charge of Professors Mayer, Morton and Himes.

Burlington is situate in Lat. N. 40° 48′ 21.″58; Long. 0h. 56m. 13.88s. W. of Washington. It was 7 miles N. of the centre of the moon's shadow.

The telescope used was by Merz & Mahler of Munich, and is the property of the Central High School of Philadelphia. It is equatorially mounted; of 6.42 inches aperture and of 9 feet focus, and is driven by one of Fraunhofer's friction governor clocks.

The sun's image was formed on the plate of the camera by a Huyghenian eye-piece, the lenses of which were specially computed to give the least aberration when they formed an image of the sun in the camera of 2.04 inches diameter. The image of a reticule of two spider threads at right angles to each other was also projected on the plate with the sun's image, and these threads were by me accurately adjusted, the one parallel, the other at right angles to the celestial equator; thus, the photographs have given precise position-angles of the contacts and of the protuberances.

A plate having a transverse slot of $\frac{1}{40}$th of an inch in breadth shot across the eye-piece by the action of a spring and thus gave the exposure during partial phase. The duration of this *flash* of the sun upon the camera has, since the eclipse, been made by me the object of an experimental determination, and by means of an electrical break-circuit clock and chronograph, I have found that the exposure of the collodion plate to the sun's image was almost exactly the $\frac{1}{500}$th of a second.

[Prof. Mayer here exhibited the camera used; explained the action of the exposing plate and how by its fall the time of exposure was electrically recorded on a chronograph fillet; and showed the arrangement of the aparatus by which he determined the time of exposure.]

While taking the photographs during partial-phase only 2 inches aperture of object-glass was used; but, during totality the full aperture was employed and the slide-plate allowed the whole beam to fall upon the plate. The exposure of the totality photographs varied from 5s. to 7s.

Forty-one perfect photographs were taken during the eclipse, and five of these were obtained during totality, which lasted 2m. 42s. The five totality pictures were taken in one minute and thirty-nine seconds.

[Prof. Mayer here exhibited copies on plate-glass, taken from the original negatives with an orthoscopic lens, and also copies on paper enlarged to about five inches in diameter. A large diagram showed more distinctly to the members the forms and positions of the protuberances.]

Photograph No. 4, taken 2.8 seconds after *observed* contact, shows a depression in the sun's limb at the position of first contact, and from this depression shoots into the sun a high lunar mountain, whose position measured from the S. point of the cusp, is about $\frac{1}{4}$th of the distance to the N. point of the same. Mr. W. S. Gilman, Jr., of New York, who observed with exquisite skill at Sioux City, Iowa, informed me that he obtained his time of first contact by seeing this mountain peak thrust itself into the sun's limb before a flattening occurred from the contact of the lower general surface of the moon.

[Prof. M. here gave an account of the geometrical methods used to determine the times and angles of contact from measurements on the cusps of the sun.]

The time of first contact deduced from approximate measures on two plates gave 13h. 2m. 1.24s., Burlington Sidereal Time, which is 1.1s. before contact as observed by Prof. Coffin, and 0.1s. before Dr. Gould's observation. From measures on another plate we deduced 13h. 1m. 57.3s., which is 4s. before contact as observed by Dr. Gould, and $\frac{6}{10}$th of a second after contact as determined by Prof. Young with his new spectroscopic method of observation.

Measures on plate No. 8 gave for the position-angle of first contact	—70°	48′
Computed angle	—71°	
Difference	—0°	12′
Plate 41 gave for position-angle fourth contact	108°	34′
Computed angle	108°	0′
Difference	+0°	34′

Sixteen spots were visible on the sun's disc during the eclipse. Two large spots, one in the S. W. quadrant, the other in the N. E., are beautifully defined on the photographs. Near the eastern point of the sun's limb is a remarkably beautiful and characteristic spot, greatly fore-shortened from its position so that the penumbra has disappeared on the west side of the umbra, against which rests the large bright faculae, which enclose the spot, while one bridges over the spot in a N. E. direction and seems to divide it into two portions. I here exhibit drawings of the spot in the S. W. quadrant which show the rapid changes which took place in the form and dimensions of this spot in 1h. 59.5m., the interval between the times of taking the plates from which they are drawn.

On plate 4, we see the umbra and penumbra of a general circular outline, with an intensely white projection into the N. W. point of the margin of the penumbra. The mean diameter of the umbra is 6,000 miles.

Plate 42 shows that the circular outlines of umbra and penumbra have changed into elliptical boundaries, the direction of the longer axis being N. W. and S. E. The umbra has widened in this direction 4″, or 1796 miles, and has, in the transverse direction, narrowed its breadth 5.″5, or 2357 miles, while the outward projections of the umbra (which can be identified on plate 4) have become greatly lengthened.

Photograph No. 15, of the series, shows this spot *bisected* by the limb of the moon.

All the photographs show a gradation of shade from the border of the sun inwards. This shading of the source of light is due to the absorption of the peripheral rays which necessarily pass through a greater thickness of the dense solar atmosphere, than those which emanate from the central portion of the disc.

We also observe on the photographs close to the limb of the moon, a bright glow like that of early dawn, which on plate No. 11 can be distinctly traced to 18″ beyond the limb of the moon. If this phenomenon cannot be explained in mode and in *measure* by diffraction, it must be due to a lunar atmosphere, though it is difficult to reconcile its existence with the inappreciable refractive effect on small stars, and especially on double stars, when occulted by the moon.

I will not attempt at present a complete description of the plates obtained during totality. I merely refer you to the diagram which I have prepared, and call your attention to those of the most remarkable protuberances. These protuberances I have numbered from 1 to 12, going from N. through E. to N.

No. 4, on the eastern limb of the sun, has the appearance of an eagle with outspread wings resting on the trunk of a tree which leans towards the north, on plate No. 27, where the base of the protuberance is cut off by the advancing moon, the resemblance to an eagle on the wing is perfect. The form of this object indicates instability, and impresses one with the idea that it is a great travelling whirl of flame, the direction of whose rotation—as indicated by the position of "the wings" and the projection of one on the other—is retrogade or in the same direction as the hands of a watch. I have examined with care the successive photographs of it, and although at first I thought the last impression differed from those preceding in that the wings had become longer and more in a line with each other, yet, on subsequent examination, I could not really decide that a perceptible motion had taken place during the time of totality.

The position-angle of the N. side of the base of this object is 96° 25′; its height is 1′ 22″, or 36,700 miles, and the spread of the wings is 9° 31′, or 70,800 miles.

On the western limb of the sun we see the remarkably large and massive protuberance No. 8. It is shaped like an albatross head, with the beak and under-side of the head resting on the periphery of the moon. On a photograph taken at Ottumwa, Iowa, just before the sun came out, this protuberance had the exact appearance of an albatross head, with the beak open, holding a rounded mass between the extremity of the jaws. It lies between the position-angles of 2[illegible]0° 13′ and 245° 46′; its length is 15° 33′, or 115,700 miles, and its greatest height is 75″, or 33,600 miles.

The protuberance No. 10, bears the most striking resemblance to a caterpillar, out of whose head issue two horns; the one nearest the front being the higher of the two, and terminated with a knob or ball from which comes a broken line of light to the border of the moon. Its mean position is 287° 33′ and it extends through 11 degrees or 81,800 miles. Its maximum elevation, which is at the head of "the caterpillar" is 52″, or 23,300 miles.

We here give a table of the position-angles and heights of the protuberances. Those on the eastern limbs of the sun, viz: 1 to 7 inclusive, were determined from measurements on the first plate of the totality series, taken 17.1 seconds after second contact; those on the western limb of the sun were determined from the last plate of totality, taken 50 seconds before third contact.

The angles of position of prominences, 1 to 7 inclusive, should be *diminished* 32.′5, to make them correspond to the positions they had on the first plate of totality; for reasons which are given in my official report.

Table of the position-angles and heights of the Prominences.

No. Prominence.	Position-angles.	Height.
1	55° 9′ to 57° 59′	22″
2	66° 14′ to 72° 21′	22″
3	87° 15′	75″
4 (base of)	96° 25′ to 98° 4′	82″
4 (tip of N. wing)	90° 39′	
4 (tip of S. wing)	100° 10′	
5	101° 23′ to 118° 36′	136″ (nebulous cloud.)
6	146° 25′ to 149° 30′	45″
7	156° 46′ to 161° 59′	37″
8	230° 13′ to 245° 46′	75″
9	273° 27′	
10	282° 13′ to 293° 12′	52″
11	315° 54′ to 321° 12′	44″
12	342° 7′ to 343° 58′	15″

Observations on the application of photography to the determination of the times of contacts during the transit of Venus in 1874 *and* 1882.

We here venture a few remarks, showing the peculiar value of photography in the observations of the transits of Venus.

It has been shown that the sun's image was photographed on the camera plate with an exposure of only $\frac{1}{500}$th of a second; and the duration of exposure for any other instrument can be determined with as great precision by the method which I employed.

The instant the mechanical movement exposes the plate, it also records the time of that exposure on a chronograph connected with a break-circuit clock, and thus we have an accurately delineated *figure* of the transit corresponding to a *time* marked on the face of the clock employed; and this correspondence of figure and time is unaffected with personal equation either of sight or of hearing. Now if the error and rate of the clock can be entirely freed from the personal equation of the observer who determined them, and if the longitude of the station be found by the coincidences of the beats of a sidereal clock with those of a break-circuit mean solar clock placed at the observatory of the first meridian, we have the most accurate means of obtaining the *absolute* times of contacts at the station of observation.

Thus we see how applicable will be photography to these observations, for the data of the solar parallax will be given either by observing *the absolute time* of the ingress or of the egress (which method is alone of value in the transit of 1874), or by determining *the duration* of the transit of Venus over the solar disc. The photographs are *permanent* phenomena on which we can repeat our measures at leisure, with every appliance of precision, while it is impossible to attain a similar degree with eye and ear, from the difficulty of micrometically measuring at a *precise* instant the distance of Venus from the sun's limb, and from the (recorded) distortions of Venus at contacts.

It will also be of great value to have a photographic record of the appearance of Venus at the contacts, for, *if* the disc of the planet then should appear on the plate to depart from a circle and have attachments to the sun's limb, these distortions can be measured and allowed for.

An idea may be formed of the apparent size of Venus during its transit of the sun's disc, from the fact that the umbra of the solar spot in the south-west quadrant is 15″ in diameter, and that Venus at transit will subtend an angle of about 70″; so that the planet would appear on the plate as a disc $4\frac{2}{3}$ times the diameter of this spot, or, as a disc of .107 inch diameter on an image of the sun of 3 inches in diameter.

The negatives of these photographs I find from trial will stand a magnifying power of 50 under the micrometer, and as 1″ of arc will equal $\frac{1}{700}$th inch on a solar image of 3 inches diameter, we can, with the above mentioned power, divide a second into ten parts. This supposes, however, that the bisection by the micrometer thread is on a perfectly well defined point, and this does not exist in the outlines of any photograph, and especially is the limb of the sun indistinct on account of its shading, and of the manner in which the silver is deposited in the collodion film.

From actual experience in measurements under the micrometer, I find that we cannot, as yet, hope to make a bisection on the sun's limb closer than $\frac{1}{2}$ of a second. On the boundary of the umbra of a well defined solar spot, we can read to $\frac{1}{4}$ of a second, and from this I should think the $\frac{2}{10}$ of a second might probably be attained as the limit in a reading on the imb of the image of Venus.

But with measures as close as these, and the tables of Venus brought to the accuracy which existing unreduced observations can give, we may reasonably hope for a determination of the solar parallax comporting with the most exact astronomical measures of this century.

The Lehigh University, Pa., 7th September, 1869.